Broadband Log-periodical Antenna with Omni-Directional Radiation Pattern in the Horizontal Plane

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***Abstract*— In this paper, a new design for a Log-periodic antenna with omni-directional radiation pattern in the horizontal plane and broad-band characteristics is investigated. This antenna covers the 500 – 3000 MHz band with VSWR < 3:1 and the gain better than 0 dBi with maximum deviation ±1.5 dB in the entire frequency bandwidth.**

I. INTRODUCTION

A complete monitoring system for accurate ITU measurement requires the ability to receive any polarization from any direction [1]. This can be done by combining both omni-directional vertical and horizontal polarization. For broadband vertically polarized antennas, there are well-known solutions [2], but a horizontally polarized antenna with broadband frequency coverage is still a challenge [3]. Therefore, for the target system, working between 20 MHz and 3000 MHz, we are aiming at two small portable antennas with horizontal polarization and omni-directional coverage. The first one, defined as low-band antenna, covers the 20–500 MHz frequency range and the second one, defined as high-band antenna, covers the 500 –3000 MHz band. The Low-Band antenna with loaded cross dipole antenna (LCDA) configuration has been reported by the authors [4]. In this paper, a new design for a Log-periodic antenna with omni-directional radiation pattern in the horizontal plane and broad-band characteristics is investigated as the High-Band Antenna

II. ANTENNA STRUCTURE

A straightforward topology to generate a horizontally omni-directional pattern is a horizontal loop antenna. However, this type of antenna has a relatively low bandwidth. Another idea is to rotate a vertical dipole and mount it horizontally. Of course, the radiation pattern is then no longer omni-directional. This problem can be tackled by using two crossed dipoles. In this case, each antenna compensates the null of the other one. Unfortunately, doing so, the radiation pattern is no longer really omni-directional over a wide frequency range, due to the change of the radiation pattern with frequency. This problem can be solved by miniaturizing and optimizing the topology of the antenna in the lower bands (low-band) [2], but for the high-band antenna, it is necessary to have an efficient antenna at lower frequencies.

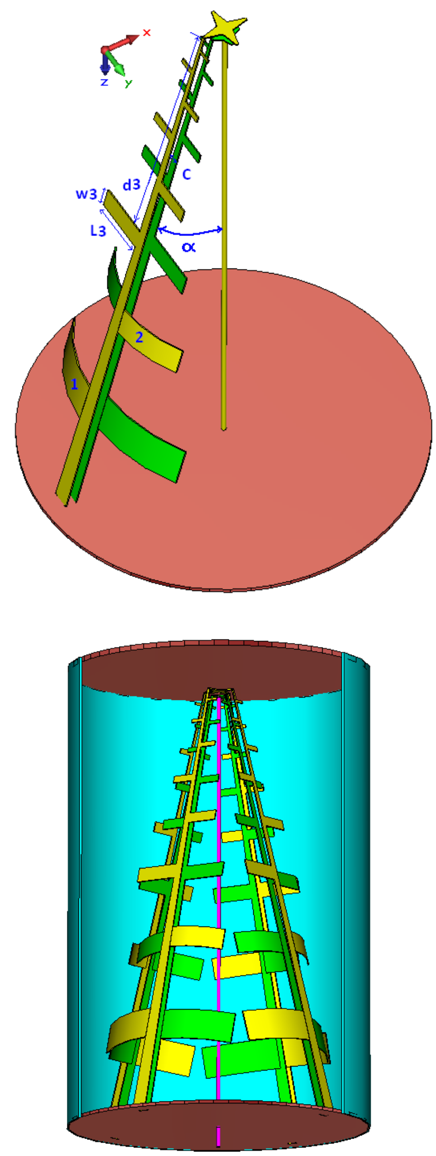

Fig. 1: Design parameters of the proposed omni-directional Log-periodic antenna

Multi-radiator antennas with orthogonal structures that branch off symmetrically from a central stem are found to be potential candidates. The turnstile antenna in Fig.2 (a) is one of the best promising structures. This structure is more suitable for circularly polarized radiation patterns but can be designed to show a good horizontal polarization [3]. Structure (b) in Fig. 2 uses four bow-tie antennas around a supporting object to obtain required omni-directional pattern [4]. Structures (c) and (d) are employing a conical pole to increase the bandwidth and to make the antenna physically smaller with omni-directional radiation pattern in horizontal plane. All of these structures are good candidate for high-band antenna requirements. But the main disadvantage of these structures is complicated feeding mechanism so that we need at least two baluns to feed these antennas and one 90 degree hybrid coupler to obtain omni-directional radiation pattern from the crossed antennas [5].

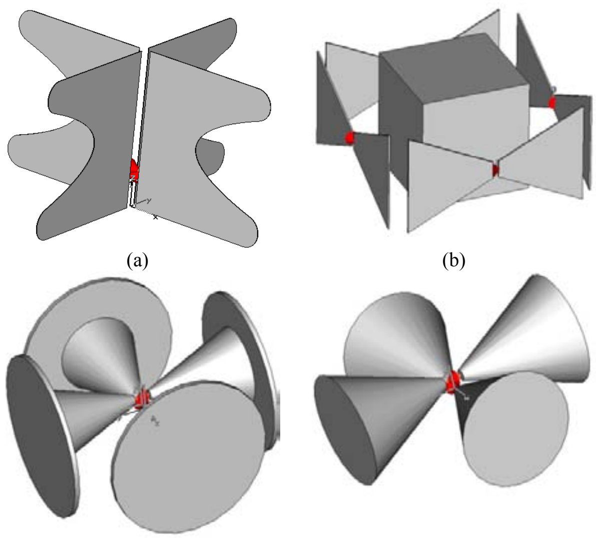

Fig. 1 Some candidate structures to obtain an omni-directional pattern in the horizontal plane.

Conventional Log-periodic antennas [6] have a frequency independent structure and are constructed from dipole elements with logarithmical scaling and appropriately fed using a common line. These antennas are good candidates for broadband horizontal polarization, but the problem is their end-fire directive radiation pattern. For omni-directional coverage, it is necessary to combine the radiation patterns of at least four twin log-periodic structures with proper feeding scheme.

Fig. 1 shows the design parameters and one twine branches of the antenna with feeding 50 Ohm coaxial cable and standing metal plate. In this antenna, two metal plates are placed at the top and the bottom of the antenna to reduce the variation of the horizontal pattern.

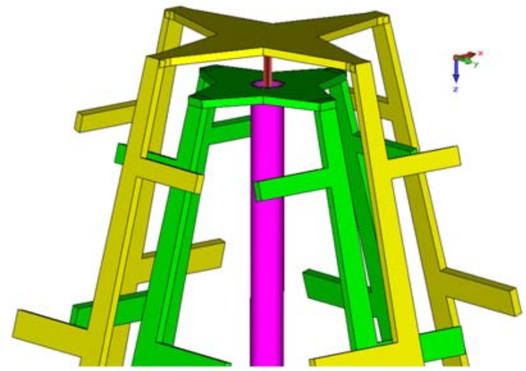

Fig. 3: Feeding details of the antenna

In Fig. 3 details of feeding point, where the coaxial cable is connected to the branches of the antenna, is shown. At this point, all upper branches are connected together and to the cable centre, while the lower branches are connected to the cable shield.

III. Design and Simulation Results

In order to optimize the antenna performance, CST microwave studio [7] is used to determine the structure parameters are shown in Fig.1. A maximum pattern flatness while keeping the VSWR smaller than 3:1 in the entire frequency band is the optimization goal. The optimized antenna parameters are given in Table.1. Simulation result of VSWR and radiation pattern for the optimized structure are presented in Fig. 4, 5 and 6. The simulation results show VSWR < 3:1 and a maximum deviation of ±1.5 dB over the whole frequency band.

TABLE.1

OPTIMIZED PARAMETERS OF THE PROPOSED ANTENNA (IN MM)

i	1	2	3	4	5	6	7	8
Li	72.4	53.9	45.2	31.5	22.1	17.2	12.8	10.6
Wi	31.0	21.4	14.7	10.2	7.0	4.8	3.3	2.3
di	349	262	192	138	94.4	60.2	33.1	11.8

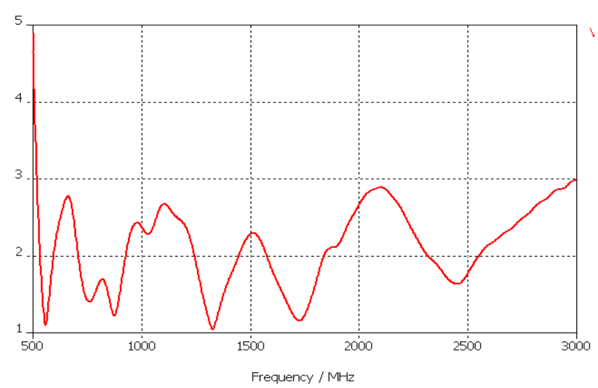

Fig. 4: Simulated VSWR vs. frequency

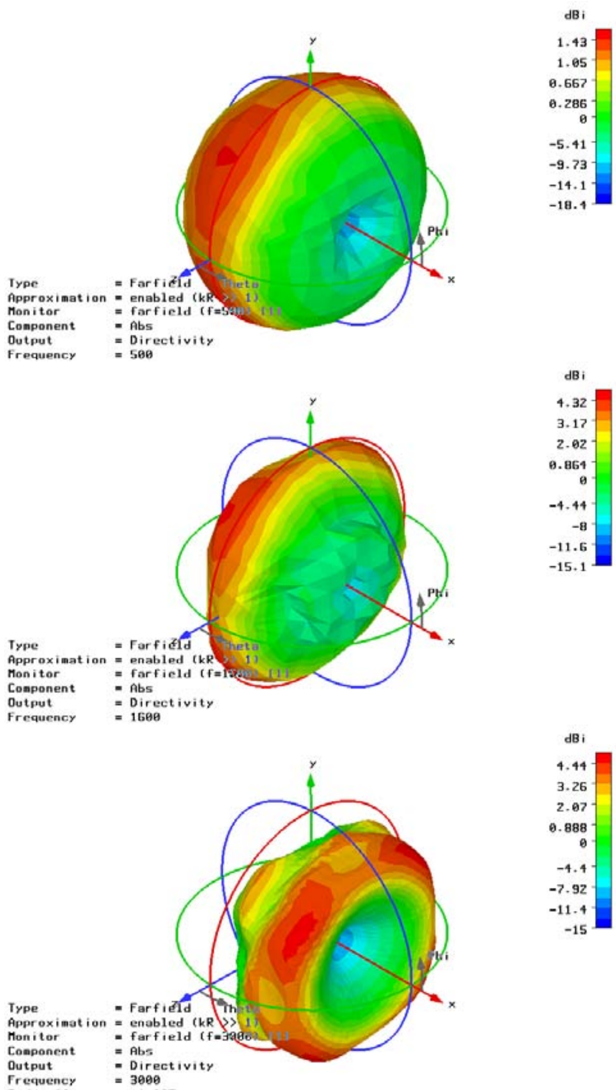

Fig. 5: Simulated 3D radiation pattern of proposed antenna at different frequencies

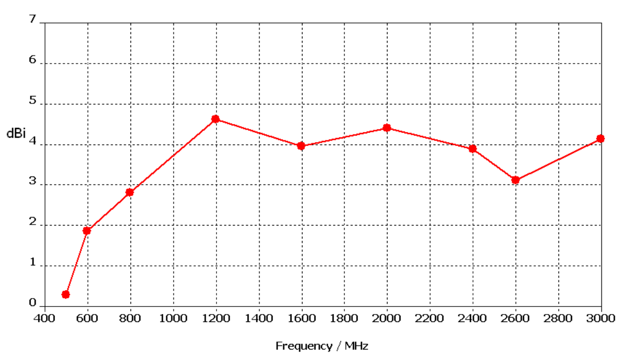

Fig. 6: Simulated antenna gain vs. frequency

IV. Construction and Measurement

The constructed antenna is shown in Fig. 7. The measured VSWR of the antenna with radome is given in Fig. 8. It can be seen that the total VSWR in the whole band is below 3:1 and is in good agreement with the simulation results.

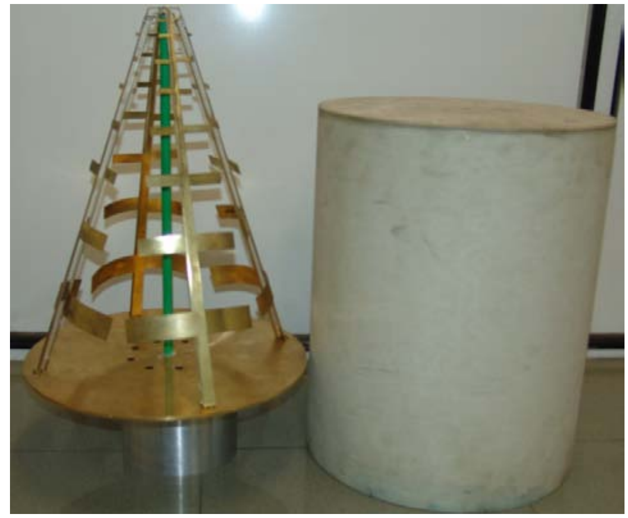

Fig. 7: Constructed antenna with proper surrounding radome

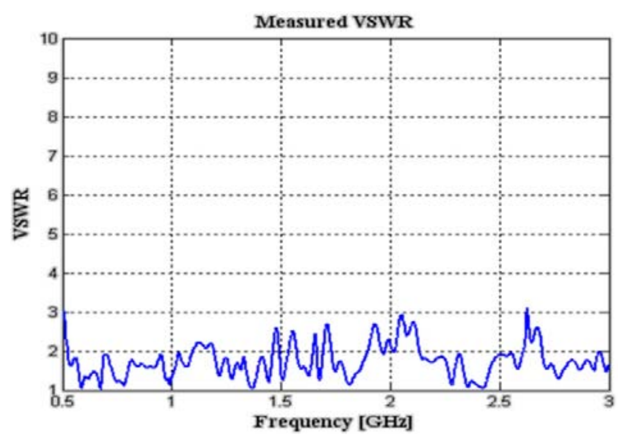

Fig. 8. Measured VSWR of the constructed antenna

V. Conclusions

In this paper a new design of a log-periodic dipole antenna, with broad-band omni-directional horizontally polarized radiation pattern in the horizontal plane has been proposed. An efficient optimization procedure based on a genetic algorithm was used to determine the dipoles length, width and location of the Log-periodic structure. The simulation results show a maximum deviation 3 dB within a ±7 degrees interval over the whole frequency band. The designed antenna was constructed and the VSWR was measured.

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